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MAINTENANCE OF THE PPES-40 POWER PLANT IN THE USSR.

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Steam mobile electric power plants with a capacity of 40 kilowatts (PPES-40) are now in use at many logging enterprises.

The PPES-40 is a rather complex power plant. Its steam assembly operates in a closed system, for which it is equipped with condenser equipment. The experience gained in operating this plant during the harsh 1949 - 1950 fall and winter season and during the past summer has confirmed the soundness of its design.

Successful operation of the PPES-40 depends to a great extent on timely and correct technical maintenance of all its parts, cleanliness of all parts, and observance of operational and lubrication directions. Proper treatment of boiler water is also very important. When basic maintenance, lubrication, and water treatment directions are violated, the boiler goes out of order frequently, the steam engine wears out prematurely, and the plant requires more repairs than planned.

Passing over the mechanics and technical characteristics of the PFES-40 since these were briefly described in *Lesnaya Promyshlennost'*, No 8, 1949, this article will be devoted to a discussion of some important maintenance and operational problems of the plant, with emphasis on water treatment and lubrication problems.

Boiler Feed Water and Its Treatment

Proper feed-water quality is most important for normal and uninterrupted operation of the boiler and engine. The boiler should be fed only pure water containing no foreign matter or solutes (saline hardness).

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As it vaporizes, the feed water for PPES-40 boilers must not leave scale deposits on the tube walls. It must not clog the boiler with silt and mud or cause the metal to corrode. Finally, the feed water must not foam and be carried into the superheating tubes.

As already stated, the boiler of the PPES-40 operates in a closed system. After its use in the engine, much of the steam is condensed; after removal of oil, the condensate is returned to the boiler. Water and condensate losses, amounting to about 10 percent per cycle, are replaced with fresh water which is fed into the system. The condensate contains no silt and saline hardness, but does contain particles of oil which were picked up by the steam while passing through the steam engine. Oil particles in the feed water have a very harmful effect on the boiler tubes; when they, together with scale, adhere to the tube walls, the burning through and breaking of the tubes is accelerated.

The quality of boiler feed water for the PPES-40, consisting of chemically purified water and condensate, should meet the following standards:

<u>Feed Water Quality Index</u>	<u>Values</u>	
	<u>Normal</u>	<u>Temporarily Permissible</u>
Total hardness, degrees (German), not more than	0.1	0.2
Total alkalinity, degrees (German), not more than	0.2	0.3
Dry residue in condensate, mg/l	5.0	10.0
Dry residue in chemically purified water, mg/l	10.0	15.0
Oxygen content in feedwater, mg/l, not more than	0.05	--
Reaction (pH)	7.5-8	--
Oil content in condensate, mg/l, not more than	2.0	5.0

An increase in hardness, alkalinity, dry residue, and oil content is permissible for not more than 50 hours, and not more frequently than once every 2-3 months.

Water fed into the boiler must not contain suspended impurities which can be removed by ordinary filtration. The normal quality of boiler water and steam must be maintained when not more than 3.5 percent of the steam is used for blowoff purposes.

Feeding unsoftened water into the boiler is permissible only when the plant is started for the first time and in cases of emergency. Each instance of feeding unsoftened water into the boiler must be recorded on a special document. After the boiler has been started and the filters of the plant have gone into action, boiler water quality is quickly restored by vigorous blowoffs.

For proper preparation of feed water which is to be admitted into the boiler, the plant is equipped with gravel and Wofatit filters, an oil separator, manual and steam-driven pumps, a pipeline, and fittings.

Suspended impurities are removed from the water by allowing them to settle. To accomplish this, it is recommended that a tank holding not less than 5 cubic meters be set up at or near the plant. The outlet from such a tank should be located somewhat above the bottom of the tank.

The gravel filter, serving as a mechanical purifier, is a steel cylinder 1,400 millimeters high, filled with about 60 liters of quartz sand particles 1.2-1.8 millimeters in diameter. The water passes through this filter from top to bottom and is then directed to the Wofatit filter. The highest water pressure in the filter is 4 atmospheres (gauge). When the gravel has become dirty, it is washed by feeding water in the opposite direction, from the bottom upwards, until the water again flows clear.

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The gravel filter will operate for about 8 hours when contamination is heavy, 30-35 hours when it is light.

After mechanical filtration, the water is conducted into the Wofatit filter for softening. Passing through it also from top to bottom, the water gives off its saline hardness to the Wofatit (Wofatit is a resinous residual product of coal or lignite distillation), that is, an exchange reaction takes place.

In PPES-40 plants of the first series, the Wofatit filter consisted of a cylinder 900 millimeters high, 250 millimeters in diameter, and with a capacity of 30 liters of Wofatit. In plants of the 1950 series, the height of the cylinder was increased to 1,200 millimeters and its volume to 40 liters of Wofatit.

Normal productivity of the earlier filter was 100 liters of water per hour, that of the larger filter is twice as great.

The length of service of the Wofatit filter without restoration (regeneration) depends above all on the hardness of the feed water.

Normal length of service of the Wofatit filter in hours can be computed by a formula, the numerator of which is the product of the volume of the filter and the coefficient of exchange (1.2) and the denominator of which is the product of the numerically expressed degrees of hardness of untreated water and feed water. Thus, the length of service of a 30-liter filter having a productivity of 100 liters of water per hour and treating water with a hardness of 10 degrees will equal

$$\frac{30 \cdot 1.2}{10 \cdot 0.1} = 36 \text{ hours.}$$

When the hardness of untreated water are 20, 30, and 40 degrees, the corresponding lengths of service are 18, 12, and 9 hours.

When the hardness of the feed water after filtration exceeds 0.1 degree, the Wofatit must be washed and restored with table salt.

Before each regeneration, the Wofatit filter is washed and stirred up with a stream of water directed upward. When the filter is to soften water with a hardness of up to 20 degrees, about 3 kilograms of table salt are necessary to restore it; when the water is harder, 4 kilograms are required. The salt can be added through the upper cover of the cylinder or can be poured into the filter in solution. The solution must stand in the filter for about 25 minutes, whereupon it is drained off through the lower valve.

Since some oil evades the oil separator, enters the feedwater tank with the condensate, and floats on the surface, it is necessary to remove this oil systematically.

Lubrication of Assemblies and Mechanisms

Lubrication of the steam engine and other mechanisms is a most important maintenance operation. The following lubricants are recommended for lubrication of the plant's various parts:

1. Cylinder oil Vapor (GOST 788-43) or cylinder oil 6 (GOST 3190-46), for lubrication of steam cylinders and feed pumps.

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2. Grease 1-13 (GOST 1631-42), for which another grease (GOST 1951-43) can occasionally be substituted, for lubrication of the bearings of the condenser equipment, exhaust fan motor, and electric generator.

3. Avtol 10 or Avtol 18 (GOST 1862-42), for use in the steam engine crankshaft and camshaft cases and for lubrication of joints and other friction surfaces of the engine.

Lubrication materials are kept in special containers to prevent their contamination. Before lubricators are filled, they should be cleaned. When oil is changed in crankcases, the cases should be thoroughly flushed so that the fresh oil is not mixed with the used. Oil should be poured into pressure lubricators only through a screen.

Recommended oils and lubrication directions for the various mechanisms of the PPES-40 are shown in the following table.

<u>Lubrication Point</u>	<u>No of Points</u>	<u>Lubricant and Volume in One Lubrication</u>	<u>Lubrication Directions</u>
Steam engine crankshaft case	1	Avtol 10 or 18; 4.5 liters	Check oil level before starting engine
Steam engine camshaft case	1	Avtol 10 or 18; 4 liters	Change oil and clean oil filter after each 100 hours of operation
Crankshaft governor case	1	Avtol 10	See that governor weights are lightly dipped in oil
Lubricator over throttle valve lever	1	Avtol 10 or any engine oil	Check daily and refill as needed
Pressure lubricator for lubrication of cylinders	1	Cylinder oil Vapor (GOST 788-43) or cylinder oil 6	Check level before starting engine; add oil as needed
Steam engine piston rods	2	Same	Lubricate with oil can several times daily
Lubricators on steam pumps	2	Same	Fill lubricators at start of shift and replenish as needed
Steam pump piston rods and slide valve rods	4	Same	Lubricate with oil can several times daily
Condenser mechanism bearings	2	Grease 1-13 (GOST 1631-42)	Check and refill lubricators every 8 hours
Condenser vane fan bearing	1	Same	Repack at least after each 2,000 hours of operation; clean bearing at same time
Exhaust fan motor bearing	3	Same	
Electric generator bearings	2	Same	Repack at least every 6 months
Automatic circuit breakers	2	Transformer oil	Fill when plant is started and check monthly; change oil annually

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General and Technical Maintenance

The responsibility for maintenance of the plant and its assemblies falls on the senior engineer, shift engineers, and assistant engineers (firemen).

At the end of a shift, the plant is carefully cleaned and the boiler blown off at a steam pressure of about 5 atmospheres. In winter, external cleaning of the plant must be especially thorough and no ice must be permitted to form under the floor of the plant and on the ends of pipes running outside; measures must be taken to prevent possible freezing of water or condensate in the pipelines, valves, and tanks.

General and technical inspections and repairs are performed, according to plan, in the following sequence:

1. Daily inspection
2. Technical maintenance No 1 -- after each 50 hours of operation (approximately weekly)
3. Technical maintenance No 2 -- after each 200 hours of operation (approximately monthly)
4. Technical maintenance No 3 -- after each 1,000 hours of operation.

Light repair work such as replacement of worn out parts is performed at each technical inspection as required.

Thus far, no extensive experience in the operation of steam mobile electric power plants has been accumulated and it is difficult to determine the exact times when medium and capital repairs should be made. However, in comparison with other similar plants it may be estimated that medium repairs should be made after 2,000-3,000 hours of operation, capital repairs after 5,000-6,000 hours. Medium and capital repairs ought to be made in special machine repair shops or at a repair plant.

Daily Inspection

Before the plant is started, the brigade which operates it must check all assemblies and see that sufficient water, fuel, lubricants, and tools are on hand. It must check the water level in the boiler and fill the fresh water tank, if necessary. It must clean the ash pit. While the boiler is being heated, it must inspect all fittings and flange joints and stop any leaks discovered while the pressure is below 5 atmospheres. The manometer is checked for accuracy. When boiler pressure reaches 25 atmospheres, the safety valves are tested.

The feed pumps are checked and lubricated, if necessary. The crankcase and pressure lubricator oil levels are checked and oil added, if needed. In winter, the oil should be preheated to 40-50 degrees before addition. Before the steam engine is started, it is ascertained that the governor stands at zero; at the same time, the condensate is drained.

Several times during the shift it will be necessary to check the oil in the crankcase and pressure lubricator and to lubricate friction parts with an oil can. While the plant is in operation, it is necessary to check all electrical instruments carefully, see that the automatic circuit breakers are working, prevent overloading of the plant, and watch the condenser unit, filters, and all other assemblies.

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Technical Maintenance No 1

The tightness of all flange joints is checked, and steam leakages are eliminated; the boiler walls and insulation are checked and repaired; the steam pipes are checked.

The valve clearances of the steam engine are checked and steam distribution is regulated. If necessary, the steam engine's governor, throttle valve, and reduction valve are adjusted.

If it is time, the gear cases are drained, cleaned, and fresh oil installed. The oil filter is cleaned, and the pressure lubricator and its packings are checked.

The plates in the oil separator are thoroughly cleaned with steam and kerosene. The oil layer is removed from the surface of the condensate in the condensate tanks.

The filters for water preparation are cleaned; the Wofatit filter is restored with table salt (depending on the hardness of the water, this operation may also be performed between technical maintenances No 1).

The electric generator and electric distribution mechanisms are inspected and cleaned of dust and dirt; the collector and generator contact rings are cleaned and polished. The contact fastenings and terminal clamps are checked and tightened. The batteries for emergency lighting as well as the charging mechanism are cleaned and checked.

Technical Maintenance No 2

Soot and ashes are removed from the boiler flue. Scale and silt accumulation in the boiler collector and distribution tubes is checked, as is bearing tightness in the crankshaft connecting rods of the steam engine.

The generator slip rings are cleaned with sandpaper.

A check is made as to whether the steam engine, electric generator, and other assemblies are fastened securely to their foundations; if necessary, they are secured.

Technical Maintenance No 3

The boiler is given a thorough cleaning. All water is drained from the boiler. The flange in the bottom of the boiler drum is opened. The flanges of the collector and distribution pipes are removed. In case the boiler has become clogged, the plugs from the rear ends of the convective condenser tubes are also removed.

The steam distribution system of the steam engine, all valve springs, and valve play are checked. The tightness of seals and packings and the working order of all lines are checked.

The steam engine is disassembled and the condition of the crankshaft connecting rod, cylinder walls, and guide cams inspected. The drive mechanism of the camshaft is checked and tightened. All bearings are inspected. Scale is removed from the bottoms of the pistons and from the valve seats.

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The radiators and condensate tanks are cleaned. The cooling surfaces of the radiators are blown off and cleaned of dust and dirt.

The filters for water preparation are cleaned and, if necessary, the quartz sand in the gravel filter and the Wofatit in the water-softening filter replaced.

The electric generator is inspected and the armature removed. If needed, the commutator sections and slip rings are ground and the carbon brushes of the slip rings replaced.

A full inspection of the electrical distribution equipment is made. The condition of the exhaust fan motor is checked.

The feed pumps are disassembled and inspected. Worn-out parts are replaced and new stuffing box packing installed. All water pipes are checked.

Not less than once annually, it is necessary to check all control and measuring instruments and protective devices. This is accomplished by sending them to a special laboratory or testing them with special calibration instruments.

The cited lists of operations to be performed by way of technical maintenance are not exhaustive. The workers servicing the plant are obligated to keep it in condition and strictly to observe factory instructions for its operation.

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